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Time inhomogeneous Stochastic Differential Equations involving the local time of the unknown process, and associated parabolic operators

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Abstract

In this paper we study time inhomogeneous versions of one-dimensional Stochastic Differential Equations (SDE) involving the Local Time of the unknown process on curves. After proving existence and uniqueness for these SDEs under mild assumptions, we explore their link with Parabolic Differential Equations (PDE) with transmission conditions. We study the regularity of solutions of such PDEs and ensure the validity of a Feynman-Kac representation formula. These results are then used to characterize the solutions of these SDEs as time inhomogeneous Markov Feller processes.

Keywords: Stochastic Differential Equations with Local Time; time inhomogeneous Skew Brownian Motion; Divergence Form Operators ; Feynman-Kac representation formula ; time inhomogeneous Markov processes

1. Introduction

1.1. Presentation

In a seminal paper on the subject [1], J.-F. Le Gall gives necessary and sufficient conditions for pathwise uniqueness property of time homogeneous one-dimensional Stochastic Differential Equations involving the Local Time (SDELT) of the unknown process, namely

$$dX_t = \sigma(X_t)dW_t + \int_{\mathbb{R}} L_t^x(X)\nu(dx), \quad t \in [0,T], \quad X_0 = x_0. \tag{1}$$

Here $T > 0$ denotes the time horizon, $x_0 \in \mathbb{R}$ is the starting point, $\sigma : \mathbb{R} \to \mathbb{R}_+^*$ is a given bounded measurable function, $\nu(dx)$ is a given bounded measure on $\mathbb{R}$, and $(L_t^x(X))_{t\in[0,T]}$ stands for the symmetric local time of the unknown process $(X_t)_{t\in[0,T]}$ at point x. Together with results on the existence of a weak solution for (1), these results on pathwise uniqueness allow to assert that (1) possesses a unique strong solution.

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